The Adaptive Spectral Reconnaissance Program

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Adaptive Spectral Reconnaissance Program Vision

- Wide Area Surveillance and Reconnaissance
- Deployed by the Commander
- Capable Against Difficult Targets
- Compatible With Current Data Dissemination Systems

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The Adaptive Spectral Reconnaissance Program (ASRP) is a recently initiated program jointly funded by DARPA and DARO. Its goal is a next generation airborne reconnaissance system using spectral imaging sensors. By spectral sensors, we refer to a sensor system utilizing more than the three bands typical of a color camera - we expect it will refer to an imaging spectrometer providing images in a hundred or more spectral bands in the 0.4-12 µm EO spectrum.

We believe that there is a significant vacant niche in military reconnaissance abilities. No EO system capable of wide area search for difficult (camouflaged) targets is available on smaller platforms available to commanders in the theater. It is our vision that spectral technologies will provide such a capability on the current generation of mid-altitude UAV’s. In order to prevent a major slow down in the acceptance of this new capability, data products will largely be compatible with the current data dissemination and analysis architectures.

ASRP Motivation

- **Enable Wide Area Search Against Difficult Targets From Small Platforms**
- **The Opportunities for UAV Reconnaissance Are Expanding**
  - Systems Include Dark Star, Global Hawk, Predator, Outrider
- **The Smaller Systems Have Certain Attractive Properties**
  - Below Clouds, Control of Commander, Cost
- **Significant Deficiencies in Electro/Optic Wide Area Surveillance**
  - Data Bandwidth Limited
  - ATR Problematic
  - Poor Capability Against Camouflage and Deception
- **New Sensor Modalities, Especially Spectral, May Enable Wide Area Search**

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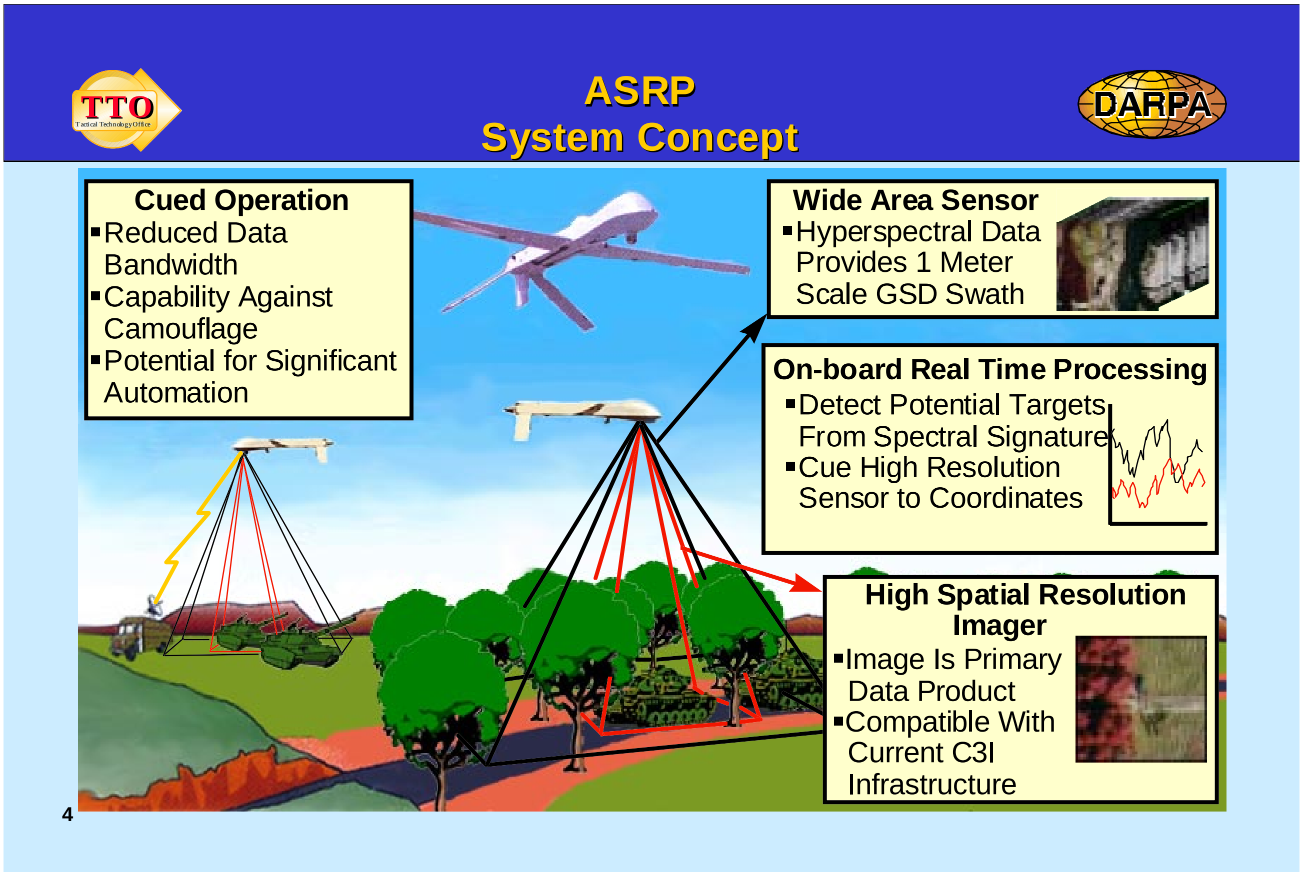
Wide area search for military targets which are either camouflaged or deceptively deployed poses a difficult problem. It is a particular problem in smaller scale conflicts where the target density is low.

Simultaneously, the Department of Defense is investing significant funds in developing new platforms for reconnaissance and surveillance. TIER 2+ and TIER 3- will be highly capable platforms with a substantial attendant infrastructure. Smaller platforms, such as Predator or smaller tactical UAV's, may be available to commanders at lower echelons to provide rapid response in a changing battlefield. In addition, these smaller platforms may exist in greater numbers and will be able to fly below clouds in many circumstances.

Providing a wide area search capability for these smaller systems is problematic. Wide area search for standard panchromatic, high resolution imagers implies large data bandwidths. Even if data compressions could solve this problem, the data analysis would be a slow, manual affair with a poor capability against decoys and deception.

Recent work indicates that newly available spectral sensors can detect targets efficiently using automatic target detection methods with as little as one pixel on target. This capability, should it prove to be robust, offers to enable wide area search against otherwise difficult to locate targets.



The system concept for ASRP uses an imaging spectrometer as part of an integrated WAS system for current medium altitude endurance UAV platforms. In this compact system, data from a spectral sensor with a meter scale GSD is used to cue a high resolution spot imager to potential targets in its 1-2 km field of view. The spectral data is analyzed in real time by an on-board processor, precluding large data rates from that sensor having to be sent to the ground.

Because the primary data product is a series of high resolution images, this system will significantly increase the effectiveness of smaller platforms without substantial changes to current communications systems and ground stations. The secondary data product, the spectra of the proposed target and the surrounding background, are, of course, available if the bandwidth allows and the mission requires.

ASRP System Development Elements: Wide Area Sensor

Current

- GFE: TRWIS III Mark 2
- Spectral Range: 0.4 - 2.5 μm
- 384 bands
- < 5% Radiometric Accuracy
- Inflight Calibration
- IFOV 0.9 mrad, 5 m GSD @ 15000’
- FOV > 13° (256 Cross Track Pixels)
- 15, 30, 60 Hz Sample Rate

Future

- Day/Night Capability
  - VIS-LWIR: 0.4-12.0 μm
- UAV Compatible (Predator)
  - Size, Weight, Power, Interfaces
- Wide FOV: 2 km @ 2km Altitude
- High Radiometric Performance
- GSD: 1 m @ 2 km Altitude
- Stabilization: < 50 mrad in 3 Axis
- Field of Regard: 45° in All Directions From Nadir

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There are several principal areas in the proposed systems which will need to be developed and integrated. The most challenging may be the wide area spectral sensor. The current commercial state of the art is exemplified by the TRWIS III hyperspectral imager. This sensor covers the spectral range of 0.4 to 2.5 mm with 384 bands. It is a push-broom sensor with 256 pixels across its field of view. It relies on reflected solar light and can only function as a daytime system.

While the specifications for the sensor to be developed have not been finalized, we can provide some of the currently anticipated characteristics. The developed spectral sensor will have day/night capability using all or part of the VIS-LWIR range (0.4 - 12.0 mm). This spectral range will be imaged in 100 or more spectral bands. The sensor will provide a wide field of view up to 2 km at a 2 km altitude with a GSD of 1 m. This sensor will have excellent radiometric characteristics, particularly the signal to noise ratio. It may be stabilized and slewable with a field of regard of 45° from nadir. The sensor will be compatible in size, weight, volume, power, and other interfaces with tactical UAV’s such as Predator.

ASRP System Development Elements: Processor

Current

- COTS Workstation
- GFE Algorithms
- Single Algorithms
- Manual Selectable Algorithms

Future

- **On-board Detection, Cueing and Recognition Processing**
  - Real Time
  - Pd & FAR/km^2 for Different Scenarios: Target in Open, Camouflage, Trees
  - Geolocate Target Pixels
  - Cue to Skyball
- **Optimized Algorithms**
  - Multiple Algorithm Adaptable
  - Scalability
- **Downlink Selectable Image Data and Target Cues**
- **Provide Waterfall Displays With Target Overlays**

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As will be pointed out later, ASRP will use a COTS workstation for the concept verification phase of the program. This processor will run a single algorithm at any time. This system will provide real time cueing to the high resolution sensor.

The future processor will be able to provide on-board detection, cueing, and recognition processing in real time. In order to provide a high probability of detection and a low false alarm rate (FAR) for different scenarios, we anticipate employing multiple detection and discrimination methods simultaneously. In addition, information from the analyst’s decisions on the high resolution video can be used to modify the system response to future cues. It will geolocate the target pixels, and then cue a skyball to those target coordinates. The processor will generate and downlink selectable image data and target cues to a ground station where waterfall displays of covered terrain with target overlay can be generated.

ASRP System Development Elements: High Spatial Resolution Sensor

Current

- GFE Provided
- Slewed
- High Resolution Video

Future

- Integrated to Wide Area Search Hyperspectral Sensor
- Spectral Capability
  - Fixed
  - Adaptive
- High Registration Accuracy to Wide Area Search Sensor
- “Electronic Cueing”

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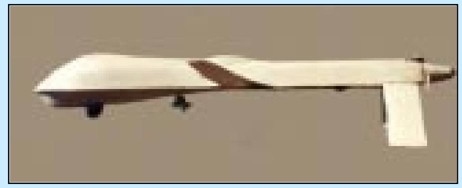
The current high spatial resolution sensor on the Predator UAV is a video camera mounted on a Skyball gimbal. This camera can be slewed to a target position based on data from the wide area hyperspectral sensor.

We anticipate that improvements on this video capability will enhance the performance of the ASRP system. For example, in order to limit registration errors and issues associated with slewing cameras, the high resolution camera may be integrated more closely with the spectral sensor. This sensor will be electronically cued and will provide a high registration accuracy to the WAS sensor. A limited spectral capability of the future sensor may provide enhanced contrast for the image analyst. This may use either a fixed multispectral approach or an adaptive sensor.

ASRP System Development Elements: Platform Integration

Current	Future
	

Sherpa Payload

- COTS Equipment
- Minimal Integration
- System Verification Testbed - Sherpa

Predator Payload

- < 100 lb. Payload
- Fully Integrated
- Field Replaceable
- Compatible with Predator and other UAV's as well as Air Reconnaissance Low (ARL)

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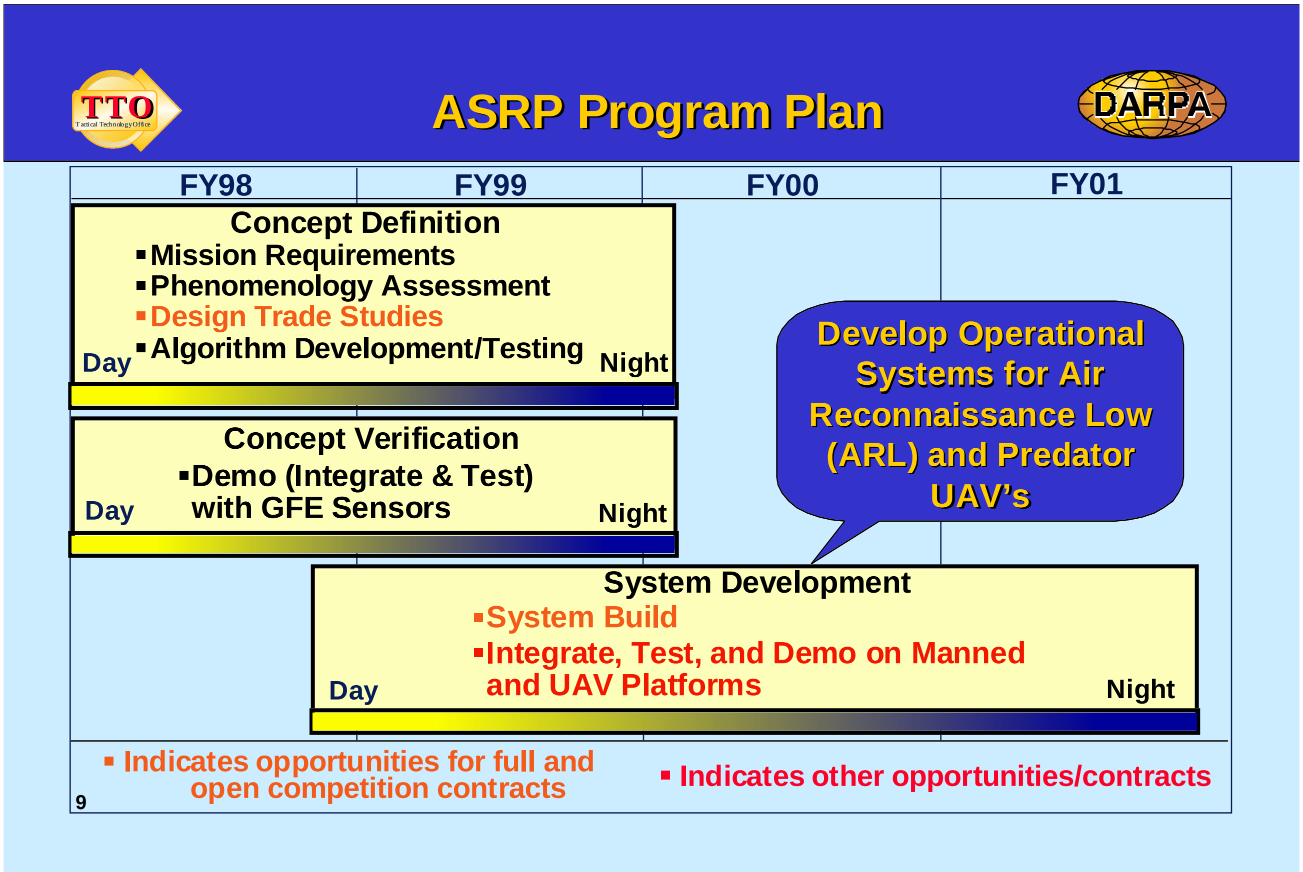
During concept verification efforts, ASRP will use an Army owned Sherpa aircraft. The payload will use COTS equipment and will only require minimal integration for testing purposes. Since the Sherpa aircraft can accommodate a 3000 lb. payload, weight and volume constraints are not an issue for the manned platform tests. The aircraft space is adequate for rack mounted components and operator consoles permitting man-in-the-loop operation.

For the system development phase, the ASRP will use the Predator UAV. The program will produce a fully integrated payload, hopefully in one or two field replaceable units. In the field, the system will be operated from the ground by a single operator, and will perform its mission with minimal human intervention. This unmanned platform can accommodate a payload of approximately 100 lb. In addition to its primary UAV application, we also anticipate the use of this sensor on other platforms such as the Army's Air Reconnaissance Low (ARL).



The ASR Program consists of three major components. The first, Concept Definition, will define the mission requirements and CONOPS. As part of this phase, a phenomenology assessment will be examined to help define the sensor characteristics. Along with the phenomenology results, a series of sensor design trade studies will be examined to fulfill the sensor requirements. This will be an opportunity for industry to participate in a full and open competition. Additionally, this phase will include the development and testing of algorithms to detect targets. This phase will begin by examining the day aspect of the system and continue to develop a day/night capability in the latter stages. The Concept Definition phase began in FY97 and will continue through FY99.

The second component, Concept Verification, will be examined simultaneously along with the Concept Definition effort. This part of the program will integrate, test, and demonstrate a slew-to-cue capability for a day system using GFE sensors on a manned aircraft.

The third phase of the program, System Development, will build, integrate, test, and demonstrate the day and day/night system on manned (Sherpa) and unmanned platforms (Predator UAV) over a period of time that begins in late FY98 and ends in FY01. The construction of the system will be accomplished by a commercial contractor chosen in full and open competition. The final product of the ASR Program will be an operational sensor system for the Air Reconnaissance Low and Predator UAV.

Summary

- **ASRP Investigating a New Model for EO Wide Area Search**
  - May Be Necessary for MAE UAV's
  - May Point to Upgrade Path for EO Systems on HAE UAV's
- **Opportunities For Industry**
  - System Design Studies (BAA FY98)
  - System Build, Test, and Integrate (RFP Late FY98)

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In summary, the Adaptive Spectral Reconnaissance Program is investigating new technologies for electro-optic wide area search on mid altitude UAV’s and manned platforms. The new advances in hyperspectral sensors and cued operation will provide the image analyst with data for detecting and identifying targets in a CC&D environment in real time. In addition to providing a needed capability for smaller platforms, the ASR Program may point an upgrade path for electro-optic systems on larger high altitude UAV’s. With various opportunities for industry to participate, the ASR Program will incorporate the newly developed technologies into a compact sensor system that will enhance the military’s reconnaissance abilities.